An Evaluation of Nass Area Chum Salmon Escapement Data, 1980–2014

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EXECUTIVE SUMMARY

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Chum Salmon (*Oncorhynchus keta*) stocks in the Nass Area of Pacific Fishery Management Area 3 are depressed with returns below the provisional escapement target (45,000) in 12 of the last 15 years. From 2007 to 2014, Nass Area Chum Salmon have: 1) returned on average 83% lower than the average return from 1980 to 2006 (18,000 vs. 103,000); 2) not met escapement goals; and 3) failed to show signs of recovery in absence of directed commercial fisheries based on the assessment data currently collected. In response to poor returns of Nass Area Chum Salmon in recent years, Fisheries and Oceans Canada (DFO) managers have reduced Canadian exploitation rates to a mean of 6% (range: 3–16%) from 2007 to 2014 compared to the 1980−2006 mean of 23% (range: 7–43%). However, recovery of Chum Salmon stocks has not occurred to date as evident in poor escapement to Nass Area streams since 2007, ranging from 3,000 (2008) to 29,000 (2014).

The data defining the Chum Salmon decline in the Nass Area are poor. Since 1980, the average number of indicator assessment streams (n = 8; Illiance River; Kitsault River; Wilauks Creek; Stagoo Creek; Kshwan River; Kincolith River; Kwinamass River; Ksemamaith Creek) surveyed by DFO with sufficient effort to produce an escapement estimate has declined from seven (1980−1989) to four (2005–2014). In 2002, 2003, and 2011, only two coastal indicator streams were surveyed by DFO (Kshwan River and Stagoo Creek). The majority (70%) of indicator estimates were of low (33%) or medium (37%) quality; only 30% were high quality estimates. The methods used to generate these escapement estimates were also varied. Most (78%) were produced using unspecified methods (48%) or subjective expert opinion (30%). Only 22% of estimates were generated using quantitative methods such as area-under-the-curve (AUC), peak count plus cumulative dead, or fence counts.

The current method used to estimate Chum Salmon escapement to the Nass Area relies on several assumptions, including that indicator stream returns co-vary and that indicator returns co-vary with non-indicator returns (English et al. 2012). Insufficient survey data were available to test these assumptions. It is also assumed that a run-timing curve based on Chum Salmon arrival at the lower Nass River fishwheels at Gitwinksihlkw is representative of Nass Area Chum Salmon as a whole. Sufficient timing data were available to determine that six current indicator systems (Illiance River, Kitsault River, Wilauks Creek, Kwinamass River, Kincolith River, and Ksemamaith Creek) support summer-run stocks, with arrival timing similar to the English et al. (2012) curve. However, run timing at Stagoo Creek and Kshwan River peak before and after the fishwheel timing curve, respectively.

Funding ($10,027) received from the Pacific Salmon Commission's Northern Fund in 2014 enabled our review of historical Chum Salmon escapement data to the Nass Area and methods

used to derive estimates from 1980 to 2014. In our review, we found that DFO has recently utilized up to four different methods to generate escapement estimates (peak count, AUC, expert opinion, and total count) and up to four different counting methods (walk, helicopter, drift boat, and float plane) to enumerate Chum Salmon escapements in Area 3. From 1994 to 2011, nearly half (42%) of possible indicator escapement estimates were not produced. For indicator streams with escapement estimates, 17% were high quality, 22% were medium quality, and 19% were low quality.

The current non-standardized approach to assessing Nass Area Chum Salmon escapement directly limits fishery managers' ability to quantify how (if) stocks co-vary, thereby severely limiting the applicability of the current escapement assessment approach that uses the indicator system approach. As a result of our review, we recommend multiple surveys are conducted in 2015 on seven indicator systems (Ksemamaith, Kshwan, Stagoo, Kitsault, Illiance, Wilauks, and Kwinamass) and eight non-indicator systems (Donahue, Lizard, Crag, Perry Bay, Tseax, Pirate Cove, Zolzap, and Gitzyon). A thorough escapement assessment of Nass Area Chum Salmon is also recommended for the next four years (2015–2018), at which point one full life cycle of Chum Salmon will be complete, and future data collection methods will be standardized, scientifically defensible, and repeatable. Standardization of the methodology offers significant advantages over the disparate methods utilized by DFO in the past and will remove current and untested assumptions used to derive Nass Area escapement and run size from indicator stream assessments.

Effective management of Nass Area Chum Salmon, and development of a recovery plan, requires accurate escapement and run size data. Consistent survey effort, improved data quality, and higher quality estimates are necessary. Escapement estimates should be based on standardized objective methods. Since 2010, the highest quality estimates for Chum Salmon streams have been AUC estimates produced by the Nisga'a Fisheries and Wildlife Department. The suitability of AUC and other methods should be evaluated for all indicator streams in the future for standardizing methods to estimate annual Nass Area Chum Salmon escapement.

INTRODUCTION

Chum Salmon (*Oncorhynchus keta*) stocks in the Nass Area (Figure 1) are depressed, with returns below provisional escapement targets (45,000) in 12 of the last 15 years (Figure 2A; Table 1). The low returns do not appear related to spawning habitat availability (Gaboury and Bocking 2007). Although habitat availability may not be a major limiting factor, Nass Area Chum Salmon have: 1) returned on average 83% lower from 2007 to 2014 than the average return from 1980 to 2006 (18,000 vs. 103,000); 2) not met escapement goals; and 3) failed to show signs of recovery in absence of directed commercial fisheries based on the assessment data currently collected. This trend is also reflected in Chum Salmon catches at fishwheels operated at Gitwinksihlkw in the lower Nass River. The number of Chum Salmon captured per hour of operation has declined since fishwheel operations began in 1994 (Figure 3). In response to poor returns of Nass Area Chum Salmon in recent years, Fisheries and Oceans Canada (DFO) fisheries managers have reduced Canadian exploitation rates to a mean of 6% (range: 3–16%) from 2007 to 2014 compared to the 1980–2006 mean of 23% (range: 7–43%; Table 1; Figure 2B). However, recovery of Nass Area Chum Salmon stocks has not occurred to date as evident in poor escapement returns to Nass Area streams since 2007, ranging from 3,000 (2008) to 29,000 (2014).

Harvest estimates of Nass Area Chum Salmon in Canadian and US fisheries from 1980 to 2014 were derived using methods from English et al. (2012). Since most of the Canadian harvest of Nass Area Chum Salmon stocks was believed to occur as bycatch in DFO statistical Area 3 Sockeye Salmon (*O. nerka*) commercial net fisheries, English et al. (2012) used weekly estimates of the catch and harvest rates for Nass Sockeye Salmon to estimate harvest rates for Nass Chum Salmon stocks. On average, from 1980 to 2014, 140,000 (range: <500–475,000) Chum Salmon have been commercially harvested each year in Area 3 (NJTC 2015). Of this mean harvest, current Nisga'a-Canada-BC Joint Technical Committee (NJTC) estimates of the Nass component is 12% (19,000 fish) with a range between <1% (<500) and 39% (141,000). Since 2000, the average commercial catch of Chum Salmon in Area 3 has declined to 55,000 fish (range: <500−166,000), well below the historical average catches. In addition, since the implementation of the Nisga'a Treaty in 2000, Nass Area Chum Salmon returns have not been strong enough to allow the Nisga'a Nation to fully harvest their annual treaty allocation, or in some years, even have an allocation (Figure 4). The annual Nisga'a Nation share of Nass Area Chum Salmon is 8% of the total return to Canada to an annual maximum of 12,000 fish (Nisga'a Final Agreement 2000). Of the total allocation (50,000 fish) since 2000, the Nisga'a Nation has only been able to harvest 9,000 fish (18% of the total allocation).

For US fisheries, the Alaskan exploitation rates for Area 3 Chum Salmon stocks were assumed to be equal to the Alaskan exploitation rates for Nass Sockeye Salmon as derived from the Pacific Salmon Treaty Northern Boundary Sockeye run reconstruction analyses (Alexander et al. 2010; English et al. 2012). On average, from 1980 to 2014, 26,000 (range: 500–141,000) Nass Area Chum Salmon were estimated to have been commercially harvested annually in Alaskan fisheries (NJTC 2015). For the same period, the estimated exploitation rates in the Alaskan fisheries averaged 26% (range: 9–57%). Since 2000, on average, the estimated harvests of Nass

Area Chum Salmon in Alaskan fisheries has declined to 7,000 each year (range: 500–25,000) with exploitation rates ranging between 9% and 40% (mean = 19%).

The decline of the Nass Area Chum Salmon stocks in recent years represents a major challenge for the sustainable management of the mixed stock fisheries on Nass Area salmon conducted in Canadian and US fisheries. Effective management of Nass Area Chum Salmon, and development of a recovery plan, requires that reliable escapement and run size data are available for these stocks. A significant challenge in addressing the apparent decline of Nass Area Chum Salmon stocks are the poor escapement data available to assess the decline. The Wild Salmon Policy (Fisheries and Oceans Canada 2009) has identified 36 Chum Salmon spawning streams from three Conservation Units (CU; Lower Nass; Portland Inlet; Portland Canal-Observatory Inlet) that cover the Nass Area. Estimates of annual Chum Salmon escapement to the Nass Area are based on aerial or ground surveys of up to eight indicator systems (22% of identified Chum Salmon streams) from these CUs (Figure 5). Escapement estimates for indicator systems are expanded to account for escapement to both un-surveyed indicator systems and to non-indicator systems (n = 28) in the Nass Area using average relative contributions to total escapement from historical survey data. This overall escapement is then expanded by a factor of 1.5 to account for underestimation bias by surveyors (English et al. 2012). Both the indicator stream escapement estimates underpinning this calculation and the historical estimates used to calculate expansion factors are of highly variable quality. This method assumes that the relative proportions of Chum Salmon returning to indicator and non-indicator systems have remained constant over time, despite the fact that some systems have not been surveyed regularly for many years. Uncertainty in escapement and run size estimates presents an obstacle to implementing a recovery plan for Nass Area Chum Salmon, an activity that has been identified as a high priority by Nass Area fishery managers.

The current escapement enumeration program for Area 3 (Nass Area) relies on several untested assumptions about returns to indicator and non-indicator streams and escapement timing. These include:

a. Returns among and between indicator streams and non-indicator streams co-vary such that surveys of a subset of these streams can reliably be expanded based on historical contributions of individual systems to the Nass Area aggregate escapement;

b. The current set of indicator streams represents a sufficient proportion of the aggregate Chum Salmon escapement to the Nass Area;

c. The historical data used to expand surveyed indicator escapement to total indicator escapement and then to total escapement for the Nass Area are accurate and adequately represent the current distribution of Chum Salmon in Nass Area streams;

d. The current timing and frequency of indicator stream surveys is appropriate to cover the Chum Salmon spawning period and allow effective escapement estimates to be derived;

e. The methods used to calculate indicator stream escapement estimates are un-biased and adequately precise;

f. An expansion factor which is applied to the overall escapement estimate to account for observer efficiency is valid for all system-specific escapement estimates (i.e., estimates for individual indicator streams have not already accounted for this bias); and

g. A run timing curve based on arrival of Chum Salmon at the lower Nass River fishwheels is representative of the run timing of Nass Area Chum Salmon as a whole (English et al. 2012).

As a result of continued low returns of Nass Area Chum Salmon in recent years and uncertainty in annual Nass Area Chum Salmon aggregate escapement estimates, the Pacific Salmon Commission (PSC) Northern Fund provided funds ($10,027) in 2014 to the Nisga'a Fisheries and Wildlife Department (NFWD) to conduct a detailed review of Area 3 stream inspection logs, BC16 escapement records, and internal reports for Nass Area Chum Salmon indicator and non-indicator streams. The primary goals of the review were to: 1) recommend indicator and non-indicator streams to survey each year to generate reliable annual Nass Area Chum Salmon escapement estimates, and 2) develop a stream survey plan for the future to refine and standardize methodologies to estimate Nass Area Chum Salmon escapement on an annual basis.

Objectives

This data review assessed the quality of stream survey data used to produce Nass Area Chum Salmon escapement estimates. Where adequate data of sufficient quality were available, the following were conducted:

1. Review DFO and NFWD escapement data for Nass Area Chum Salmon streams and determine the quality of escapement estimates using DFO criteria (addresses assumptions a, c, d, e, & f; Table 2);
2. Tabulate arrival timing and peak spawning date by system and relate these data to the Chum Salmon run-timing curve recommended by English et al. (2012) (assumptions d & g);
3. Conduct statistical analyses to test the assumption that escapements co-vary among indicator systems (assumption a);
4. Conduct statistical analyses to test the assumption that indicator and non-indicator stream escapements co-vary (assumption a); and
5. Summarize the findings and make recommendations on what indicator and non-indicator streams to survey each year to generate reliable annual Nass Area Chum Salmon escapement estimates.

METHODS

A detailed review and comparison of DFO and NFWD stream inspection logs (SILs) with DFO BC16 records, Stream Estimate Narrative (SEN) data, and the DFO New Salmon Escapement Database (NuSEDS; Tompkins and Baxter 2015) was conducted. Bruce Baxter (DFO Nanaimo, BC) and Peter Hall (DFO Prince Rupert, BC) provided the BC16, SEN, SILs, and NuSEDS data. Our review focused on 1994–2011 to correspond with the timeframe used for the Chum Salmon migration timing curve utilized in English et al. (2012), but information prior to 1994 was also reported if available. Nisga'a Fisheries and Wildlife Department reports were reviewed for Nass Area non-indicator and indicator streams. Parameters evaluated included: 1) number of years with escapement estimates; 2) the number of annual surveys per stream; 3) survey methods; 4) survey timing; 5) date and size of peak counts; 6) NuSEDS escapement estimate; and 7) escapement estimation method.

Peak count expansion has not generally been used for deriving Chum Salmon escapement estimates in the Nass Area (D. Peacock, DFO, Prince Rupert, BC, pers. comm.). However, where expert opinion or an unspecified method was used to produce an escapement estimate, the expansion factor from the peak count to the NuSEDS escapement estimate was calculated. It is not known if peak counts were considered in expert opinion estimates, but they provide some indication of the difference between field observations and the final NuSEDS escapement estimate.

Area-under-the-curve (AUC) escapement estimates have been generated over the years by DFO for some Nass Area streams. The AUC methodology requires estimates of the number of live fish over the run timing period (expanded from raw counts using observer efficiency) and estimates of residence time (days). The residence time most commonly used is survey life, defined as the number of days that fish are alive in a survey area (Perrin and Irvine 1990). For all NuSEDS AUC estimates reviewed for Nass Area Chum Salmon streams, we assume that residence time refers to survey life. For the British Columbia central coast, Perrin and Irvine (1990) found that the average survey life for Chum Salmon was 10 days. Observer efficiency is typically estimated by surveyors using professional judgement and is defined as the proportion of fish observed. It is not clear how observer efficiency was determined and applied to count data by DFO for the various AUC estimates for Nass Area Chum Salmon.

The quality of each escapement estimate was quantified using criteria established by DFO in 2005 (Table 2). For 2005 to 2011, these quality values were included in the BC16 database. For 1994 to 2004, the criteria were used to assign data quality values based on SILs records, if not already specified in the SEN data.

RESULTS

Indicator Streams

Eight indicator streams are currently used to index Chum Salmon escapement estimates in the Nass Area: 1) Illiance River; 2) Stagoo Creek; 3) Wilauks Creek; 4) Kwinamass River; 5) Kshwan River; 6) Kincolith River; 7) Ksemamaith Creek; and 8) Kitsault River (Figure 5). On average, five coastal indicator streams were surveyed annually by DFO from 1980 to 2014 (Table 1). However, the average number of coastal indicator streams surveyed each year by DFO has declined from seven (1980–1989) to four (2005–2014; Figure 6). In 2002, 2003, and 2011, only two coastal indicator streams were surveyed (Kshwan River and Stagoo Creek). In 2005, and since 2009, NFWD has conducted surveys on Ksemamaith Creek, the only surveyed indicator stream in the Lower Nass CU.

From 1994 to 2011, escapement data quality for the eight indicator streams ranged from 2 (high) to 6 (no estimate) in individual years. With an average escapement estimate quality of 4, Illiance and Stagoo creeks had the best average data quality. The remaining indictor streams averaged either no estimate or produced low quality estimates (Table 3).

When escapement estimate quality data for 1994–2011 were pooled for indicator streams (18 years times 8 streams; n = 144), 42% were classified as having no estimate (Table 4). These streams were either not surveyed or had very low counts (i.e., classified as having adults present). An additional 41% of escapement estimates were classified as either 4 or 5, indicating a medium to low quality estimate. Only 17% were classified as high quality estimates.

Six escapement estimation methods were used for Nass Area Chum Salmon. For most indicator streams prior to 2004, the method used was not specified. After 2004, estimate methodology was specified in the BC16 database and included: 1) expert opinion; 2) AUC; 3) peak live plus cumulative dead (DFO); 4) peak live plus dead times two (NFWD); and 5) fence counts. Expert opinion was the most common method, followed by AUC, fence counts, and peak count methods (Figure 7).

Escapement Estimates

Table 1 provides estimates of Nass Area Chum Salmon escapement to the eight indicator streams and expanded to an aggregate escapement from 1980 to 2014 using the methods of English et al. (2012). The following sections describe the quality of escapement estimates by indicator stream based on estimates currently documented in BC16 and NuSEDS databases.

Illiance River

Illiance River has one of the better survey records of the eight indicator streams (Table 5). It was surveyed every year from 1994 to 2011, with the number of annual surveys ranging from one to 13. Survey quality was ranked 3 (high) for nine years from 1994 to 2011 and rank 6 in only five years. Most escapement estimates were based on three or more surveys in a year.

When specified, escapement estimates were based on either expert opinion or AUC. On average, escapement estimates were 2.4 times the peak count (range: 1.5–3.7). Chum Salmon escapement ranged from 170 (2010) to 4,000 (1994–1995) from 1994 to 2011, and have averaged <500 (113–500) since 2011 (Table 1).

For AUC estimates, the methodology used was inconsistent. In 2006, two AUC estimates were calculated with different survey lives (10 d and 15 d) and in 2009, observer efficiency was estimated at 100% despite countability characterized as fair to good. For both AUC years, the estimate calculated using a 10 d survey life (Perrin and Irvine 1990) was used in NuSEDS. In 2011, sufficient surveys were conducted for a potential AUC or other objective estimate, but the escapement was entered as "Adults Present" (AP) in BC16 and NuSEDS.

Stagoo Creek

Stagoo Creek has the best escapement survey record of all the Nass Area Chum Salmon indicator streams. It was surveyed every year from 1994 to 2011, with at least three surveys conducted per year (Table 6). Estimate quality averaged 4 (medium), but was ranked 3 (high) or 4 in most years. When specified, escapement estimates were based on AUC, expert opinion, or peak live plus cumulative dead methodology. On average, escapement estimates were 2.0 times the peak count (range: 1.2–4.0). Chum Salmon escapement ranged from 640 (2008) to 30,000 (1998 and 2003) from 1994 to 2011, and have averaged 8,000 (7,100–8,200) since 2011 (Table 1).

From 2005 to 2010, AUC estimates were generated. However, these estimates did not follow a consistent methodology. Observer efficiency was recorded as 100% for four years, despite stream visibility ranging from poor to good. The AUC estimate for 2005 was not used for the BC16 record as it was close to the expert opinion estimate. AUC residence time also varied between 10 and 15 days, with no reference provided for these values.

Wilauks Creek

Wilauks Creek was surveyed in most years from 1994 to 2011. However, from 2002 to 2011, estimate quality was poor due to low counts, single surveys, or no surveys (Table 7). The average escapement estimate quality was 5 (low). Most escapement estimates were based on expert opinion or unspecified methodology. The exception was in 2005 when AUC was used (70% OE and 10 d survey life). On average, escapement estimates were 2.6 times the peak count (range: 1.7–4.8). Chum Salmon escapement estimates ranged from 60 (2009) to 2,000 (1998) from 1994 to 2011, and have averaged <500 (56–300) since 2011 (Table 1).

Kwinamass River

Kwinamass River was surveyed multiple times each year from 1994 to 2011 (Table 8). Both boat and aerial surveys were conducted and Chum Salmon were observed in all years. However, escapement estimates were only produced for seven of 18 years (39%). Estimates were based on unspecified methodology or expert opinion and had low quality. On average, estimates were 3.6 times the peak count (range: 1.4–7.1).

No Chum Salmon escapement estimates have been produced for Kwinamass River since 2001. Survey timing and counts in years with estimates (1994–1999; 2001) were similar to years without estimates. It is assumed that the low counts and survey timing (i.e., timed for Chinook (*O. tshawytscha*) and Pink (*O. gorbuscha*) salmon surveys) were the reasons why estimates were not produced.

Kshwan River

Kshwan River has been surveyed at least once each year from 1994 to 2011 (Table 9). Surveys included the lower reaches of four unnamed tributaries or side channels, but not every tributary or side channel was counted during each survey. All estimates were based on unspecified methodology or expert opinion and the average quality was low (Table 3). In 10 years, escapement estimates in NuSEDS are based on single surveys where Chum Salmon counts were expanded by 1.0 to 13.6 times. There was no explanation for the wide range of expansions from the observed counts. Chum Salmon escapement estimates have varied widely (average: 7,716) from 500 (2010) to 50,000 fish (1998) from 1994 to 2011, and have averaged 1,000 since 2011 (Table 1).

Kincolith River

Escapement estimates for Chum Salmon in Kincolith River were limited to years when a counting fence was installed on the river (1995–1996, 2001, and 2005–2008; Table 10). From 1994 to 2011, the weir was operational near the river mouth for eight years and escapement was based on the total Chum Salmon count (Alexander 1997; Stephens et al. 1998; Alexander and Stewart 2008). For fence operations, escapement estimate quality ranged from 2 (high) to 5 (low). Years with low and medium quality estimates were related to timing; the weir did not operate for the entire Chum Salmon run. In 2002, despite a fence count of 88 Chum Salmon, escapement in NuSEDS was entered as AP (adults present).

For years without the fence, estimate quality was poor due to lack of surveys, poor visibility, or methodology (helicopter). Given the low number of Chum Salmon spawning in Kincolith River, a counting fence is the only feasible method of collecting accurate counts. Chum Salmon escapement to Kincolith River ranged from 20 (2006) to 200 (1995) from 1994 to 2008. No Chum Salmon escapement surveys of the system have occurred since 2008.

Ksemamaith Creek

Although surveyed eight times by DFO from 1980 to 1993, Ksemamaith Creek was not re-surveyed until 2005 when NFWD conducted four surveys and an AUC estimate was produced (OE = 98%; residence time = 7 days; NFWD 2006). No surveys were conducted from 2006 to 2008, but since 2010, NFWD have produced medium to high quality confidence-bounded AUC escapement estimates for Ksemamaith Creek (Table 11; NFWD 2011–2015). At least four Chum

Salmon surveys have been conducted each year since 2010, with escapement ranging from 20 (2013) to 80 (2011) from 2010 to 2014 (Table 1).

Kitsault River

Escapement estimates for Kitsault River typically include counts from five to seven tributaries, including Dak River (Figure 8; Table 12). Dak River is the largest component of Kitsault River escapement estimates and in years when Dak River was not surveyed, no escapement estimates were generated. Since 2002, no escapement estimates have been produced due to insufficient surveys, low counts, and/or the absence of Dak River counts. In years with an escapement estimate, estimates were generated using unspecified methodology and survey quality was ranked 4 (medium). On average, peak counts were expanded by 3.2 times (range: 1.4–8.6). Chum Salmon escapement estimates ranged from 870 (2001) to 12,530 (1998) from 1994 to 2011. Since 2011, only one escapement estimate has been produced (Table 1) and this estimate (100) may not meet DFO NuSEDS inclusion criteria (Tompkins and Baxter 2015).

Timing and Return Covariation Among Indicator Systems

Sufficient run-timing data were available to determine that six current indicator systems (Illiance River, Stagoo Creek, Kitsault River, Wilauks Creek, Kincolith River, and Ksemamaith Creek) support summer-run stocks, with peak spawner counts observed in early to mid-August (Figure 9). Surveys in these systems typically span the entire spawning period. In contrast, Kshwan River Chum Salmon stocks return as a late-summer or fall run (Figure 9E). The actual timing for Kshwan River fish is uncertain due to the lack of survey effort; in many years, only one survey was conducted (Table 9). Kwinamass River Chum Salmon timing is also not well defined due to a lack of survey effort in September and October (Figure 9F); most effort was focused in August. Kwinamass River Chum Salmon stocks seem to be a late summer stock, with peak counts observed from mid-August to late September. More survey effort in mid-late September would help define the timing of the Kwinamass River Chum Salmon stock.

The English et al. (2012) assumption that the run timing curve for Chum Salmon at the lower Nass River fishwheels is representative of the overall Nass Area Chum Salmon run timing seems reasonable for most indicator systems (Figure 9). The exceptions are Stagoo Creek and Kshwan River. Stagoo Creek has the earliest run timing of all the indicator systems, peaking about two weeks earlier than at the fishwheels (Figure 9B). The peak of the Kshwan River stock appears to be later than at the fishwheels (Figure 9E) but the timing of this run is poorly defined by the 1994–2011 data. Jantz et al. (1989) define the peak in Kshwan River as mid-September with spawning ending in late October.

Insufficient data were available to statistically test if returns of Chum Salmon spawners co-vary among indicator streams. Even less data were available from non-indicator systems. Very few non-indicator systems have been surveyed sufficiently to generate a reliable escapement estimate (Table 13).

Non-Indicator Streams

Twenty-eight non-indicator Chum Salmon streams are located in the Nass Area (Table 13; Figure 5). From 1994 to 2011, most survey effort on these streams was in the Portland Inlet and Portland Canal-Observatory Inlet CUs. Very little effort was spent surveying streams in the Lower Nass CU. However, since 2010, NFWD has conducted a minimum of four stream walks for Chum Salmon on a Tseax River side-channel (NFWD 2011–2015) and Chum Salmon were also documented by NFWD in Gitzyon Creek from 2012 to 2014 (NFWD 2013–2015).

In the Portland Canal-Observatory Inlet CU, Donahue and Perry Bay creeks had the highest peak counts (Table 13). Sufficient data were collected in Perry Bay Creek from 1994 to 1998, 2001, and 2006 to produce Chum Salmon escapement estimates ranging from 30 (1994) to 1,500 (1998). Many of these observations or escapement estimates were based on one to four surveys. Greater survey effort in these two systems could potentially provide high quality escapement estimates.

In the Portland Inlet CU, Chum Salmon spawners have often been observed in Crag and Lizard creeks. Chum Salmon counts were made during Pink or Coho (*O. kisutch*) salmon surveys but insufficient data were collected to generate escapement estimates in most years. The exceptions were 2004 to 2006 when escapements in Crag and Lizard creeks ranged from 50−280 and 200−600 Chum Salmon, respectively. These streams are good candidates for Chum-specific surveys based on ease of access, countability, and relative size of returns.

DISCUSSION

The challenge of managing Nass Area Chum Salmon, accurately identifying its status, and informing a recovery plan is exacerbated by poor escapement data quality. Unreliable and inconsistent estimates of Chum Salmon escapement make managing the fishery to an agreed upon exploitation rate challenging. The overall trend toward reduced survey effort on indicator streams by DFO since 1980 (Figure 6) poses a significant challenge to addressing the apparent decline of Nass Area Chum Salmon stocks in the Nass Area as the data defining the decline are very poor.

This escapement data review reveals the non-standardized approach to assessing Nass Area Chum Salmon stocks untaken by DFO. Survey effort has declined in recent years and the majority of escapement estimates are based on subjective expert opinion. The peak count expansions used to evaluate the expert opinion estimates in NuSEDS ranged widely from 1.0 to 13.6 (Kshwan River, 1999; Table 9) times the peak survey count. The average expansions for indicator systems ranged from 2.0 (Stagoo Creek) to 3.6 (Kwinamass River). While recognizing that peak count expansion is not an escapement estimation method typically used for Nass Area streams, it does indicate that some expansion of stream counts is occurring. In the English et al. (2012) method for calculating the overall Chum Salmon return to the Nass Area, the NuSEDS escapements are further expanded three times. The first expansion accounts for un-surveyed indicator streams and the second accounts for non-indicator streams. The final expansion (1.5 times) is to account for underestimation bias of surveyors. The subjective expansion of survey counts using expert opinions to produce the initial NuSEDS estimates is already accounting for this observer efficiency bias. The additional 1.5 times expansion could overestimate the return of Chum Salmon to the Nass Area, making the low returns observed since 2006 even more concerning.

Survey timing in relation to Chum Salmon spawning and the number of surveys conducted are highly variable among indicator streams. In some cases, single surveys have been used to produce escapement estimates (e.g., Kshwan River); in other cases, several surveys were conducted but no estimates were produced (e.g., Kitsault River; Kwinamass River). This lack of effort, consistency, and objectivity has produced either no estimate or low quality escapement estimates for most indicator systems since 1994. The indicator system approach requires that escapement to index streams co-vary, but with the current data collected, it is not possible to test this assumption. This severely limits the applicability of the indicator system approach as it is currently applied to Chum Salmon in the Nass Area.

For indicator systems where escapement estimates include tributary streams (i.e., Kitsault River; Kshwan River), the number of tributaries surveyed and the number of surveys per tributary varied among and within years. In Kitsault River, the number of tributaries surveyed varied from one to seven. The Dak River tributary consistently had the highest Chum Salmon count, but has not been included in surveys since 2008 (Table 12). For all years without a Dak River survey, no escapement estimate was produced. Dak River should be included in all Kitsault River surveys. Further, the number of other tributaries surveyed must also be consistent. At Kshwan River, counts are based on surveys of up to four tributaries or side channels. Not all tributaries or side channels were surveyed each year, making count comparisons difficult. Kshwan River data quality also suffers due to a lack of effort as typically only one survey is conducted (Table 9).

Refinement and standardization of Nass Area Chum Salmon stock assessment is essential for developing a recovery plan for these stocks. Without high quality and reliable stock assessment data, it is not possible to effectively manage this species in the Nass Area or to recognize changes in the population. Improving stock assessment for Nass Area Chum Salmon is a high priority for Nass Area fisheries managers, especially given the exceptionally poor escapements observed since 2006. By applying an objective assessment methodology (e.g., AUC; mean count) with more survey effort, the assumptions underpinning the current escapement estimation procedure can be tested and evaluated. Standardizing an appropriate objective escapement estimation method that is applied to all surveyed indicator streams should be a priority for the Nass Area.

Efforts to produce high quality Chum Salmon escapement estimates were initiated by NFWD in 2005. Since then, the Nisga'a Lisims Government has funded expanded Chum Salmon assessment activities in the lower Nass River. Nisga'a Fisheries and Wildlife Department now conduct at least four surveys annually on two lower Nass River tributaries (Ksemamaith Creek and a groundwater fed tributary of Tseax Slough). Results of these surveys produced confidence bounded AUC escapement estimates for these systems (NFWD 2011–2014). Ksemamaith Creek is an indicator stream and has had the highest quality escapement estimates of all Nass Area indicators since 2010. Although the methodology was not consistent, DFO has produced AUC estimates for Illiance River (2006, 2009), Stagoo Creek (2006–2010), and Wilauks Creek (2005). With increased survey effort, a consistent objective methodology could be applied to all Nass Area indictor streams.

Nisga'a Fisheries and Wildlife Department crews have also conducted reconnaissance surveys of a number of lower Nass River and coastal systems to assess presence/absence of Chum Salmon, run timing, and to assess the feasibility of conducting more comprehensive escapement survey projects. These systems included Zolzap Creek, Kincolith River, Gitzyon Creek, Tseax Slough, Tseax River, Keaszoah Creek, and various channels where Vetter Creek water enters the Nass River from upwelling through the lava beds (NFWD 2011–2014). In 2012 and 2013, NFWD crews also conducted reconnaissance surveys of coastal tributaries entering Portland Inlet and Portland Canal. Systems surveyed included Chambers Creek, Walt Creek, Roberson Creek, Belle Bay Creek, Donahue Creek, and Georgie River.

Fisheries and Oceans Canada SILs records for several non-indicator Chum Salmon streams in the Portland Inlet and Portland Canal-Observatory Inlet CUs identified Chum Salmon, but in most cases, escapement estimates were not produced. These systems included Perry Bay, Lizard, and Crag creeks. Most observations were made during Pink or Coho salmon surveys. Chum-focused surveys on these systems could help determine if non-indicator stream escapement co-varies with indicator streams.

RECOMMENDATIONS

1. Increase the number of indicator streams surveyed each year and conduct at least three surveys spanning the peak count per stream. Sufficient data should be collected to produce high quality escapement estimates. These data are essential to define the apparent decline in Chum Salmon stocks and to evaluate if returns to indicator systems co-vary as assumed by English et al. (2012);
2. Evaluate the applicability of different quantitative escapement estimation methodologies (e.g., AUC, peak count plus cumulative dead) and standardize the method used to produce Nass Area Chum Salmon estimates;
3. Survey non-indicator streams to determine if Chum Salmon returns co-vary with indicator streams (as assumed by English et al. 2012) and to assess the current distribution of Chum Salmon spawning in the Nass Area. Possible streams include Crag, Lizard, Donahue, Perry Bay, Zolzap, and Gitzyon creeks. Each of these systems has recent records of Chum Salmon returns and they are distributed through the three Nass Area conservation units;
4. Evaluate the current suite of indicator streams. Other systems may be more suitable as indicators. For example, Kwinamass River has low Chum Salmon counts, is relatively difficult to survey due to its location and length, and may not be appropriate as an indicator system;

5. Conduct a thorough escapement assessment of Nass Area Chum Salmon for the next four years (2015–2018), at which point one full life cycle of Chum Salmon will be complete, and future data collection methods will be standardized, scientifically defensible, and repeatable. Standardization of the methodology offers significant advantages over the disparate methods utilized by DFO in the past and will remove current and untested assumptions used to derive Nass Area escapement and run size from indicator stream assessments;
6. For 2015, conduct a minimum of four Chum Salmon escapement surveys on seven indicator systems (Ksemamaith, Kshwan, Stagoo, Kitsault, Illiance, Wilauks, and Kwinamass) and eight non-indicator systems (Donahue, Lizard, Crag, Perry Bay, Tseax, Pirate Cove, Zolzap, and Gitzyon) for generating the annual aggregate Nass Area escapement estimate and collecting data to standardize estimates between years; and
7. Evaluate survey life and observer efficiency for variation within and among streams surveyed.

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TABLES

Table 1. Nass Area Chum Salmon escapement, harvest, and exploitation rates from 1980 to 2014 (NJTC 2015).

	Escapement to Nass Area Indicator Streams[a]								Nass Area Escapement			Canadian Harvests						Exploitation Rates			
Year	Illiance River	Kitsault River	Ksemamaith Creek	Kshwan River	Kincolith River	Kwinamass River	Stagoo Creek	Wilauks Creek	Obs.[b]	EF[c]	Est.[d]	Nisga'a[e]	Other[f]	Total	Total Return to Canada	US Harvest[g]	Total Run	Nisga'a	Other Can.	US	Total
1980	3,000	8,600		20,000	100	800	1,500	1,000	35,000	1.6	55,646		52,304	52,304	107,950	141,011	248,960		21%	57%	78%
1981	500	3,700	10	4,000	200	500	1,500	100	10,510	1.6	16,687		7,400	7,400	24,087	23,891	47,978		15%	50%	65%
1982	400	800	25	10,000		100	500	100	11,925	1.6	19,005		10,691	10,691	29,696	6,145	35,841		30%	17%	47%
1983	2,500	5,300	20	10,000	25	100	12,000	550	30,495	1.6	48,417		40,937	40,937	89,354	33,417	122,771		33%	27%	61%
1984	5,000	6,500		8,000	200	500	15,000	1,000	36,200	1.6	57,554		63,614	63,614	121,168	43,126	164,294		39%	26%	65%
1985	1,500	1,000		20,000	1	500	2,000	250	25,251	1.6	40,146		18,465	18,465	58,612	16,138	74,749		25%	22%	46%
1986	1,200	3,000		20,000		150	2,500	75	26,925	1.6	42,969		24,577	24,577	67,546	50,120	117,666		21%	43%	63%
1987	1,300	2,250	25	15,000		50	3,600		22,225	1.6	36,037		23,716	23,716	59,752	21,769	81,521		29%	27%	56%
1988	350	1,500	100	15,000		100	1,000	250	18,300	1.6	29,164		8,847	8,847	38,011	20,816	58,827		15%	35%	50%
1989	2,000	3,000	20	10,000	20		10,000		25,040	1.6	40,979		23,002	23,002	63,982	39,459	103,441		22%	38%	60%
1990	10,000	1,000	20	6,500			8,000	500	26,020	1.6	41,538		19,601	19,601	61,139	37,061	98,199		20%	38%	58%
1991	1,000	1,000	20	10,000		100			12,120	2.2	27,216		19,768	19,768	46,984	15,025	62,008		32%	24%	56%
1992	1,506	3,000				100	3,500	700	8,806	3.3	28,622	200	25,556	25,756	54,378	13,361	67,739	0%	38%	20%	58%
1993	2,000	5,000		50,000		100	5,000	300	62,400	1.6	99,468	416	141,217	141,633	241,101	85,761	326,862	0%	43%	26%	70%
1994	4,000	8,500				10	10,000	400	22,910	3.3	74,463	579	31,507	32,086	106,549	44,451	151,000	0%	21%	29%	51%
1995	4,000	6,000		10,000	200	50	10,000	1,000	31,250	1.6	49,643	402	33,820	34,222	83,865	30,684	114,549	0%	30%	27%	57%
1996	400	1,320		10,000	50	100	4,000	450	16,320	1.6	25,926	269	14,635	14,904	40,829	21,066	61,896	0%	24%	34%	58%
1997	350			10,000		100	2,000	150	12,600	1.8	22,864	227	8,016	8,243	31,107	22,643	53,749	0%	15%	42%	57%
1998	3,000	12,530		50,000		50	30,000	2,000	97,580	1.6	155,546	983	27,371	28,354	183,900	108,814	292,715	0%	9%	37%	47%
1999	1,500	1,500		2,000		50	17,000	300	22,350	1.6	35,627	846	32,272	33,118	68,745	20,775	89,520	1%	36%	23%	60%
2000	1,200	1,696		2,000			6,500	300	11,696	1.6	18,793	1,067	6,607	7,674	26,467	4,072	30,539	3%	22%	13%	38%
2001	1,000	870		2,000	104	50	15,000	250	19,274	1.6	30,730	1,617	3,942	5,559	36,289	18,463	54,752	3%	7%	34%	44%
2002				3,000			5,000		8,000	1.9	15,055	132	2,917	3,049	18,105	1,763	19,867	1%	15%	9%	24%
2003				5,000			30,000		35,000	1.9	65,867	318	11,324	11,642	77,509	11,280	88,789	0%	13%	13%	26%
2004	1,500			15,000			12,000	400	28,900	1.7	50,514	1,030	6,906	7,936	58,449	25,095	83,544	1%	8%	30%	40%
2005	300		70	2,000	126		15,000	260	17,756	1.7	30,739	698	2,241	2,939	33,677	9,124	42,802	2%	5%	21%	28%
2006	1,800			15,000	20		13,000		29,820	1.8	52,652	1,110	7,637	8,747	61,399	13,098	74,497	1%	10%	18%	29%
2007				1,000	95		4,900		5,995	1.9	11,221	932	884	1,816	13,037	8,672	21,709	4%	4%	40%	48%
2008				1,000	24		640		1,664	1.9	3,115	506	168	674	3,789	465	4,254	12%	4%	11%	27%
2009	475		51	1,500			9,800	60	11,886	1.7	20,680	139	1,064	1,203	21,883	7,685	29,568	0%	4%	26%	30%
2010	170		68	500			4,200		4,938	1.8	8,723	102	202	304	9,026	1,073	10,099	1%	2%	11%	14%
2011			80	1,170			2,200		3,450	1.9	6,461	210	392	602	7,062	1,477	8,539	2%	5%	17%	24%
2012	113		32	1,100			7,925	56	9,226	1.7	16,070	316	393	709	16,779	2,266	19,046	2%	2%	12%	16%
2013	500	100	20	1,100	NI	AP	7,100	300	9,120	1.6	14,480	111	563	674	15,154	2,314	17,468	1%	3%	13%	17%
2014	419	AP	25	NI	NI	NO	8,200	63	8,707	3.3	29,155	553	540	1,093	30,247	3,751	33,999	2%	2%	11%	14%
Averages:																					
1980–1989	1,800	3,600	30	13,200	100	300	5,000	400	24,000	1.6	39,000		27,000	27,000	66,000	40,000	106,000		25%	34%	59%
1990–1999	2,800	4,400	20	18,600	100	100	9,900	600	31,000	2.0	56,000	500	35,000	36,000	92,000	40,000	132,000	0%	27%	30%	57%
2000–2009	1,000	1,300	100	4,800	100	100	11,200	300	17,000	1.8	30,000	800	4,000	5,000	35,000	10,000	45,000	3%	9%	21%	33%
2010–2019	300	100	50	1,000			5,900	100	7,000	2.1	15,000	300	400	1,000	16,000	2,000	18,000	1%	3%	13%	17%

[a] Data are from the DFO New Salmon Escapement Database (NuSEDS). None Observed (NO); Adults Present (AP); Not Inspected (NI).

[b] Sum of the annual surveyed indicator stream escapements as documented in NuSEDS.

[c] Expansion factor to account for non-surveyed indicator systems, escapement to non-indicator systems, and observer efficiency for each year. Method was developed by the Pacific Salmon Foundation (English et al. 2012).

[d] Estimated Nass Area escapement (product of observed escapement and expansion factor).

[e] Nisga'a catch from annual reports by Nisga'a Fisheries and Wildlife Department (see Mathews et al. 2012).

[f] Canadian marine commercial catch is estimated from methods developed by the Pacific Salmon Foundation (English et al. 2012) and include commercial harvests in net fisheries only.

[g] US commercial catch is estimated from methods developed by the Pacific Salmon Foundation (English et al. 2012).

Table 2. Fisheries and Oceans Canada classification system for quality of Pacific salmon escapement estimates.

Escapement Estimate Class	Estimate Quality	Description
1	High	An estimate of high resolution from an unbreached fence count. The estimate uncertainty is believed to be less than plus or minus 10% of the actual estimate.
2	High	An estimate of high resolution based on documented measured data.
3	High	An estimate of high resolution based on three or more documented inspections of walking, floating, or flying which clearly define the peak of spawning and contain high adult live estimates with high fish countabilities; Or an estimate of medium resolution based on documented data from a Mark & Recapture, Fixed Site method, or medium to high AUC calculation. The estimate uncertainty is believed to be less than plus or minus 25% of the actual estimate.
4	Medium	An estimate of medium resolution based on the documentation of two or more walking, floating, or flying inspections around the peak of spawning containing high adult live estimates with high fish countabilities; Or possibly low reliable fence count records, Mark & Recapture data or low to medium AUC calculation. The estimate uncertainty is believed to be no better than plus or minus 25% of the actual estimate.
5	Low	Low Resolution.
6	No Estimate	None Observed (NO); Adults Present (AP); Not Inspected (NI); Do Not Spawn (DNS); Fry Present (FP).

Table 3. Average data quality for Chum Salmon escapement estimates from indictor streams in the Nass Area from 1994 to 2011. Numbers in parentheses are the number of survey methods used.

	Indicator Stream Escapement Estimate Quality[a]							
Year	**Illiance**	**Stagoo**	**Wilauks**	**Kwinamass**	**Kshwan**	**Kincolith**	**Ksemamaith**	**Kitsault**
1994	3 (1)	4 (2)	5 (1)	5 (2)	6 (1)	6 (2)	6 (0)	4 (2)
1995	3 (1)	3 (2)	5 (1)	5 (2)	4 (1)	5 (2)	6 (0)	4 (1)
1996	3 (1)	5 (2)	4 (1)	5 (3)	5 (1)	5 (2)	6 (0)	4 (1)
1997	3 (2)	5 (2)	4 (1)	5 (2)	5 (1)	6 (1)	6 (0)	6 (1)
1998	3 (2)	3 (3)	3 (2)	5 (3)	4 (1)	6 (0)	6 (0)	4 (2)
1999	4 (1)	3 (3)	4 (1)	5 (2)	5 (1)	6 (0)	6 (0)	4 (1)
2000	3 (1)	3 (3)	4 (1)	6 (3)	5 (1)	6 (0)	6 (0)	4 (1)
2001	3 (1)	4 (3)	3 (1)	5 (3)	5 (1)	3 (2)	6 (0)	4 (1)
2002	6 (1)	4 (2)	6 (1)	6 (2)	5 (1)	6 (2)	6 (0)	6 (0)
2003	6 (1)	4 (2)	6 (1)	6 (2)	5 (1)	6 (1)	6 (0)	6 (1)
2004	5 (1)	3 (2)	4 (1)	6 (2)	5 (1)	6 (2)	6 (0)	6 (1)
2005	4 (1)	3 (2)	4 (1)	6 (2)	5 (1)	4 (2)	4 (1)	6 (1)
2006	4 (1)	3 (1)	6 (1)	6 (3)	5 (1)	4 (1)	6 (0)	6 (2)
2007	6 (0)	3 (1)	6 (0)	6 (2)	5 (1)	2 (1)	6 (0)	6 (0)
2008	6 (1)	3 (1)	6 (1)	6 (2)	6 (1)	3 (1)	6 (0)	6 (1)
2009	3 (1)	3 (1)	4 (1)	6 (2)	4 (1)	6 (1)	3 (1)	6 (0)
2010	4 (1)	4 (1)	6 (1)	6 (2)	5 (1)	6 (0)	4 (1)	6 (1)
2011	6 (1)	4 (1)	6 (0)	6 (2)	5 (1)	6 (1)	3 (1)	6 (1)
Best	3	3	3	5	4	2	3	4
Worst	6	5	6	6	6	6	6	6
Mean	4	4	5	6	5	5	5	5

[a] Escapement estimate quality (see Table 2 for full description): 1, 2, & 3 = high; 4 = medium; 5 = low; 6 = no estimate.

Table 4. Summary of Nass Area Chum Salmon indicator stream escapement estimate quality from 1994 to 2011.

	Escapement Estimate Quality[a]					
	6	**5**	**4**	**3**	**2**	**1**
Count	61	28	31	23	1	0
%	42%	19%	22%	16%	1%	0%

[a] Escapement estimate quality (see Table 2 for full description): 1, 2, & 3 = high; 4 = medium; 5 = low; 6 = no estimate.

Table 5. Summary of Illiance River Chum Salmon escapement estimates from 1994 to 2011.

		Survey Dates		Method			Peak			AUC				Escapement[c]	
Year	Number of Surveys	First	Last	Survey	Escapement Estimate[a]	Chum Countability[b]	Date	Count	Expansion	O.E. (%)	R.T. (days)	No. Surveys	Estimate	NuSEDS	Quality
1994	4	20-Jul	12-Sep	Walk	Not Specified	Fair	27-Aug	1,650	2.4					4,000	3
1995	10	20-Jul	09-Oct	Walk	Not Specified	Good	01-Aug	2,377	1.7					4,000	3
1996	10	20-Jul	05-Oct	Walk	Not Specified	Good	13-Aug	184	2.2					400	3
1997	9	09-Aug	10-Oct	Walk, Heli	Not Specified	Excellent	07-Sep	227	1.5					350	3
1998	13	16-Jul	11-Oct	Walk, Heli	Not Specified	Fair	11-Aug	1,044	2.9					3,000	3
1999	10	26-Jul	05-Oct	Walk	Not Specified	Fair	20-Aug	401	3.7					1,500	4
2000	10	03-Aug	12-Oct	Walk	Not Specified	Good	09-Sep	678	1.8					1,200	3
2001	12	31-Jul	12-Oct	Walk	Not Specified	Good	30-Aug	290	3.4					1,000	3
2002	1	20-Aug	-	Walk	No Estimate	Good	-	520						AP	6
2003	1	28-Aug	-	Walk	No Estimate	Not Recorded	-	568						AP	6
2004	3	09-Aug	08-Sep	Walk	Expert Opinion	Fair	09-Aug	437	3.4					1,500	5
2005	9	08-Jul	19-Sep	Walk	Expert Opinion	Good	17-Aug	178	1.7					300	4
2006[d]	3	08-Aug	11-Sep	Walk	AUC	Fair to Good	27-Aug	884		80	10	3	1,806	1,800	4
2007	1	-	-	Not Recorded	No Estimate	No Data	-	12						AP	6
2008	2	07-Aug	09-Sep	Walk	No Estimate	Good	-	8						AP	6
2009	4	10-Aug	24-Sep	Walk	AUC	Fair to Good	24-Aug	209		100	10	3	472	475	3
2010	4	17-Jul	15-Sep	Walk	Expert Opinion	Good	10-Aug	116	1.5					170	4
2011	7	26-Jul	15-Sep	Walk	No Estimate	Not Recorded	-	19						AP	6
Min	1						01-Aug	8	1.5	80	10	3	472	170	3
Max	13						07-Sep	2,377	3.7	100	10	3	1,806	4,000	6
Avg	6						18-Aug	545	2.4	90	10	3	1,139	1,515	4

[a] From DFO BC16 records and Stream Estimate Narrative data.

[b] Countability at peak count or range for AUC estimates (from Stream Inspection Logs).

[c] Escapement estimate quality (see Table 2 for full description): 1, 2, & 3 = high; 4 = medium; 5 = low; 6 = no estimate. AP = Adults Present.

[d] Two AUC estimates were produced in 2006 using different values for survey life (10 d & 15 d). Using 15 d survey life, the escapement estimate was 1,204. The estimate using 10 d survey life was used for NuSEDS.

Table 6. Summary of Stagoo Creek Chum Salmon escapement estimates from 1994 to 2011.

		Survey Dates		Method			Peak			AUC				Escapement[c]	
Year	Number of Surveys	First	Last	Survey	Escapement Estimate[a]	Chum Countability[b]	Date	Count	Expansion	O.E. (%)	R.T. (days)	No. Surveys	Estimate	NuSEDS	Quality
1994	8	30-Jun	08-Sep	Walk, Plane	Not Specified	Fair	03-Aug	3,500	2.9					10,000	4
1995	8	06-Aug	07-Oct	Walk, Plane	Not Specified	Fair	06-Aug	6,500	1.5					10,000	3
1996	9	24-Jul	29-Aug	Walk, Plane	Not Specified	Poor	18-Aug	1,275	3.1					4,000	5
1997	5	06-Aug	04-Sep	Walk, Plane	Not Specified	Good	09-Aug	500	4.0					2,000	5
1998	13	16-Jul	22-Oct	Walk, Plane, Heli	Not Specified	Good	01-Aug	20,000	1.5					30,000	3
1999	7	01-Aug	15-Sep	Walk, Plane, Heli	Not Specified	Good	07-Aug	8,706	2.0					17,000	3
2000	7	02-Aug	13-Sep	Walk, Plane, Heli	Not Specified	Good	14-Aug	4,140	1.6					6,500	3
2001	6	29-Jul	10-Sep	Walk, Plane, Heli	Not Specified	Fair	11-Aug	9,511	1.6					15,000	4
2002	3	11-Aug	10-Sep	Walk, Heli	Not Specified	Fair	21-Aug	3,100	1.6					5,000	4
2003	6	25-Jul	25-Aug	Walk, Heli	Not Specified	Fair	11-Aug	18,050	1.7					30,000	4
2004	6	02-Jul	31-Aug	Walk, Heli	Expert Opinion	Good	13-Aug	8,520	1.4					12,000	3
2005	6	13-Jul	03-Sep	Walk (5), Heli (1)	Expert Opinion	Fair	08-Aug	7,500	2.0	80	10	3	16,506	15,000	3
2006	6	25-Jul	02-Sep	Walk	AUC	Poor to Good	04-Aug	6,140		100	13	4	13,162	13,000	3
2007	5	27-Jul	13-Sep	Walk	AUC	Fair to Good	27-Jul	2,740		100	15	5	4,894	4,900	3
2008	4	29-Jul	08-Sep	Walk	AUC	Fair to Good	22-Aug	172		100	10	4	633	640	3
2009	5	18-Jul	07-Sep	Walk	AUC	Poor to Good	08-Aug	5,559		100	12	5	9,800	9,800	3
2010	4	15-Jul	05-Sep	Walk	AUC	Poor to Fair	11-Aug	2,000		85	10	4	4,193	4,200	4
2011	3	27-Jul	16-Sep	Walk	Peak Live + Cum. Dead	Good	-	1,868	1.2					2,200	4
Min	3						27-Jul	172	1.2	80	10	3	633	640	3
Max	13						22-Aug	20,000	4.0	100	15	5	16,506	30,000	5
Avg	6						08-Aug	6,099	2.0	94	12	4	8,198	10,624	4

[a] From DFO BC16 records and Stream Estimate Narrative data.

[b] Countability at peak count or range for AUC estimates (from Stream Inspection Logs).

[c] Escapement estimate quality (see Table 2 for full description): 1, 2, & 3 = high; 4 = medium; 5 = low; 6 = no estimate.

Table 7. Summary of Wilauks Creek Chum Salmon escapement estimates from 1994 to 2011.

		Survey Dates		Method			Peak			AUC				Escapement[c]	
Year	Number of Surveys	First	Last	Survey	Escapement Estimate[a]	Chum Countability[b]	Date	Count	Expansion	O.E. (%)	R.T. (days)	No. Surveys	Estimate	NuSEDS	Quality
1994	3	20-Jul	12-Sep	Walk	Not Specified	Not Recorded	20-Aug	236	1.7					400	5
1995	9	20-Jul	09-Oct	Walk	Not Specified	Fair	01-Aug	532	1.9					1,000	5
1996	10	20-Jul	05-Oct	Walk	Not Specified	Fair	13-Aug	115	3.9					450	4
1997	5	09-Aug	07-Sep	Walk	Not Specified	Excellent	07-Sep	85	1.8					150	4
1998	13	16-Jul	23-Oct	Plane, Walk	Not Specified	Fair	11-Aug	413	4.8					2,000	3
1999	9	05-Aug	05-Oct	Walk	Not Specified	Not Recorded	20-Aug	132	2.3					300	4
2000	10	03-Aug	31-Oct	Walk	Not Specified	Poor	17-Aug	95	3.2					300	4
2001	12	31-Jul	29-Oct	Walk	Not Specified	Fair	30-Aug	139	1.8					250	3
2002	1	20-Aug	-	Walk	No Estimate	Poor	20-Aug	149						AP	6
2003	1	-	-	Volunteer	No Estimate	Not Recorded	-	86						AP	6
2004	3	09-Aug	08-Sep	Walk	Expert Opinion	Fair	20-Aug	191	2.1					400	4
2005	7	23-Jul	09-Sep	Walk	AUC	Fair	17-Aug	108		70	10	5	263	260	4
2006	3	08-Aug	11-Sep	Walk	No Estimate	Not Recorded	08-Aug	13						AP	6
2007	0	-	-	Not Surveyed	No Estimate	Not Surveyed	-							NO	6
2008	2	07-Aug	09-Sep	Walk	No Estimate	Good	-	2						AP	6
2009	4	10-Aug	24-Sep	Walk	Expert Opinion	Poor	10-Aug	26	2.3					60	4
2010	3	17-Jul	15-Sep	Walk	No Estimate	Not Recorded	10-Aug	3						AP	6
2011	0	-	-	Not Surveyed	No Estimate		-							blank	6
Min	0						08-Aug	2	1.7	70	10	5	263	60	3
Max	13						07-Sep	532	4.8	70	10	5	263	2,000	6
Avg	5						16-Aug	145	2.6	70	10	5	263	506	5

[a] From DFO BC16 records and Stream Estimate Narrative data. AP = Adults Present; NO = None Observed; blank = no data in NuSEDS.

[b] Countability at peak count or range for AUC estimates (from Stream Inspection Logs).

[c] Escapement estimate quality (see Table 2 for full description): 1, 2, & 3 = high; 4 = medium; 5 = low; 6 = no estimate.

AP = Adults Present; NO = None Observed; blank = no entry in NuSEDS.

Table 8. Summary of Kwinamass River Chum Salmon escapement estimates from 1994 to 2011.

		Survey Dates		Method			Peak			Escapement[c]	
Year	Number of Surveys	First	Last	Survey	Escapement Estimate[a]	Chum Countability[b]	Date	Count	Expansion	NuSEDS	Quality
1994	11	24-Jul	29-Aug	Float, Plane	Not Specified	Good	-	3	3.3	10	5
1995	9	31-Jul	20-Sep	Float, Plane	Not Specified	Good	20-Sep	12	4.2	50	5
1996	6	05-Aug	22-Sep	Float, Plane, Heli	Not Specified	Fair	22-Sep	27	3.7	100	5
1997	7	31-Jul	19-Sep	Float, Plane	Not Specified	Poor	19-Sep	26	3.8	100	5
1998	8	21-Jul	21-Aug	Float, Plane, Heli	Expert Opinion	Good	21-Aug	37	1.4	50	5
1999	10	28-Jul	01-Sep	Float, Plane, Jetboat	Expert Opinion	Good	01-Sep	27	1.9	50	5
2000	7	02-Jul	02-Sep	Float, Plane, Heli	No Estimate	Fair	-	1		AP	6
2001	5	30-Jul	08-Sep	Float, Plane, Heli	Expert Opinion	Fair	17-Aug	7	7.1	50	5
2002	6	04-Aug	06-Sep	Float, Heli	No Estimate	Good	-	2		AP	6
2003	8	09-Jul	27-Aug	Float, Heli	No Estimate	Fair	21-Aug	8		AP	6
2004	5	15-Jul	31-Aug	Float, Heli	No Estimate	Fair	22-Aug	48		AP	6
2005	4	08-Aug	24-Aug	Float, Heli	No Estimate	Fair	10-Aug	27		AP	6
2006	5	26-Jul	19-Aug	Float, Heli, Jetboat	No Estimate	Fair	18-Aug	23		AP	6
2007	5	21-Jul	23-Aug	Float, Heli	No Estimate	Good	23-Aug	22		AP	6
2008	3	08-Aug	22-Aug	Heli, Walk	No Estimate	Good	-	0		NI	6
2009	4	22-Jul	27-Aug	Float, Heli	No Estimate	Good	19-Aug	11		AP	6
2010	5	18-Jul	28-Aug	Float, Heli	No Estimate	Fair	18-Jul	30		AP	6
2011	5	09-Jul	11-Sep	Float, Heli	No Estimate	Good	-	95		AP	6
Min	3						18-Jul	0	1.4	10	5
Max	11						22-Sep	95	7.1	100	6
Avg	6						23-Aug	23	3.6	59	6

[a] From DFO BC16 records and Stream Estimate Narrative data.

[b] Countability at peak count (from Stream Inspection Logs).

[c] Escapement estimate quality (see Table 2 for full description): 1, 2, & 3 = high; 4 = medium; 5 = low; 6 = no estimate.

AP = Adults Present; NI = Not Inspected.

Table 9. Summary of Kshwan River Chum Salmon escapement estimates from 1994 to 2011.

		Survey Dates		Method			Peak			Escapement[c]	
Year	Number of Surveys	First	Last	Survey	Escapement Estimate[a]	Chum Countability[b]	Date	Count	Expansion	NuSEDS	Quality
1994	1	23-Jul	-	Walk	No Estimate	Poor	-	2		NI	6
1995	2	27-Aug	21-Sep	Walk	Not Specified	Good	-	5,265	1.9	10,000	4
1996	2	22-Aug	07-Sep	Walk	Not Specified	Excellent	-	6,575	1.5	10,000	5
1997	1	07-Sep	-	Walk	Not Specified	Good	-	4,849	2.1	10,000	5
1998	3	01-Aug	07-Oct	Walk	Not Specified	Good	09-Sep	36,090	1.4	50,000	4
1999	1	15-Sep	-	Walk	Expert Opinion	Good	-	147	13.6	2,000	5
2000	1	22-Sep	-	Walk	Expert Opinion	Fair	-	211	9.5	2,000	5
2001	1	17-Sep	19-Oct	Walk	Expert Opinion	Fair	-	724	2.8	2,000	5
2002	1	21-Sep	-	Walk	Expert Opinion	Fair	-	1,261	2.4	3,000	5
2003	1	23-Sep	24-Sep	Walk	Expert Opinion	Fair	-	1,988	2.5	5,000	5
2004	1	06-Sep	-	Walk	Expert Opinion	Fair	-	7,772	1.9	15,000	5
2005	2	17-Aug	11-Sep	Walk	Expert Opinion	Fair	-	1,043	1.9	2,000	5
2006	3	13-Aug	12-Sep	Walk	Expert Opinion	Fair	12-Sep	9,920	1.5	15,000	5
2007	2	31-Aug	12-Sep	Walk	Expert Opinion	Fair	-	519	1.9	1,000	5
2008	1	15-Sep	-	Walk	Expert Opinion	Excellent	-	977	1.0	1,000	6
2009	3	13-Sep	25-Sep	Walk	Expert Opinion	Good	14-Sep	769	2.0	1,500	4
2010	1	16-Sep	-	Walk	Expert Opinion	Excellent	-	381	1.3	500	5
2011	1	15-Sep	-	Walk	Expert Opinion	Good	-	1,162	1.0	1,170	5
Min	1						09-Sep	2	1.0	500	4
Max	3						14-Sep	36,090	13.6	50,000	6
Avg	2						11-Sep	4,425	3.0	7,716	5

[a] From DFO BC16 records and Stream Estimate Narrative data.

[b] Countability at peak count.

[c] Escapement estimate quality (see Table 2 for full description): 1, 2, & 3 = high; 4 = medium; 5 = low; 6 = no estimate.

NI = Not Inspected.

Table 10. Summary of Kincolith River Chum Salmon escapement estimates from 1994 to 2011.

		Fence or Survey Dates[a]		Method				Escapement[e]	
Year	Number of Surveys	First	Last	Survey[b]	Escapement Estimate	Chum Countability[c]	Fence Count[d]	NuSEDS	Quality
1994	4	04-Aug	29-Aug	Plane, Walk	No Estimate	Poor to Fair		NO	6
1995	4	12-Jul	04-Aug	Fence, Plane	Fence Count		193	200	5
1996	1	21-Jun	22-Aug	Fence, Plane	Fence Count		57	50	5
1997	1	09-Aug	-	Plane	No Estimate	Poor		blank	6
1998	0	-	-	Not Surveyed	No Estimate			NI	6
1999	0	-	-	Not Surveyed	No Estimate			NI	6
2000	0	-	-	Not Surveyed	No Estimate			NI	6
2001	2	15-Jun	26-Aug	Fence, Heli	Fence Count		104	104	3
2002	3	06-Jun	23-Aug	Fence, Heli	No Estimate		88	AP	6
2003	2	03-Aug	08-Aug	Heli	No Estimate	Poor		NI	6
2004	2	06-Aug	31-Aug	Walk, Heli	No Estimate	Poor		NI	6
2005	2	06-Jun	03-Sep	Fence, Heli	Fence Count		126	126	4
2006	1	15-Jun	04-Sep	Fence	Fence Count		20	20	4
2007	1	20-Jun	01-Nov	Fence	Fence Count		95	95	2
2008	1	11-Jun	22-Oct	Fence	Fence Count		24	24	3
2009	1	27-Aug	-	Heli	No Estimate	Good		NI	6
2010	0	-	-	Not Surveyed	No Estimate			NI	6
2011	1	11-Sep	-	Heli	No Estimate			AP	6
Min	0						20	20	2
Max	4						193	200	6
Avg	1						88	88	5

[a] Dates are for the NFWD counting fence if it was operating.

[b] Chum Salmon were never observed during aerial surveys. Escapement estimates are only available from fence counts.

[c] Only provided for aerial surveys.

[d] Data references include: Alexander 1997; Stephens et al. 1998; Alexander and Stewart 2008.

[e] Escapement estimate quality (see Table 2 for full description): 1, 2, & 3 = high; 4 = medium; 5 = low; 6 = no estimate.
AP = Adults Present; NI = Not Inspected; NO = None Observed; blank = no entry in NuSEDS.

Table 11. Summary of Ksemamaith Creek Chum Salmon escapement estimates from 1994 to 2011.

		Survey Dates		Method		Peak			AUC				Escapement[a]	
Year	Number of Surveys	First	Last	Survey	Escapement Estimate	Date	Count	Expansion	O.E. (%)	R.T. (days)	No. Surveys	Estimate	NuSEDS	Quality
1994	0	-	-	Not Surveyed	No Estimate	-							NI	6
1995	0	-	-	Not Surveyed	No Estimate	-							NI	6
1996	0	-	-	Not Surveyed	No Estimate	-							NI	6
1997	0	-	-	Not Surveyed	No Estimate	-							NI	6
1998	0	-	-	Not Surveyed	No Estimate	-							NI	6
1999	0	-	-	Not Surveyed	No Estimate	-							NI	6
2000	0	-	-	Not Surveyed	No Estimate	-							NI	6
2001	0	-	-	Not Surveyed	No Estimate	-							NI	6
2002	0	-	-	Not Surveyed	No Estimate	-							NI	6
2003	0	-	-	Not Surveyed	No Estimate	-							NI	6
2004	0	-	-	Not Surveyed	No Estimate	-							blank	6
2005	4	31-Jul	10-Sep	Walk	AUC	19-Aug	19		98	7	4	83	70	4
2006	0	-	-	Not Surveyed	No Estimate	-							blank	6
2007	0	-	-	Not Surveyed	No Estimate	-							blank	6
2008	0	-	-	Not Surveyed	No Estimate	-							blank	6
2009	2	31-Aug	10-Sep	Walk	Peak Live + Dead	31-Aug	23[b]	2.1					51	3
2010	5	23-Aug	22-Sep	Walk	AUC	26-Aug	29[b]		92	7	5	82	68	4
2011	4	31-Jul	22-Sep	Walk	AUC	28-Aug	18[b]		78	7	4	80	80	3
Min	2					19-Aug	14		78	7	4	80	51	3
Max	5					31-Aug	29		98	7	5	83	80	6
Avg	4					25-Aug	22		0	7	4	82	67	5

[a] Escapement estimate quality (see Table 2 for full description): 1, 2, & 3 = high; 4 = medium; 5 = low; 6 = no estimate.

NI = Not Inspected; blank = no entry in NuSEDS.

[b] Data references for 2009 count: NFWD 2010; 2010 count: NFWD 2011; 2011 count: NFWD 2012.

Table 12. Summary of Kitsault River Chum Salmon escapement estimates from 1994 to 2011.

		Survey Dates				Method			Peak			Escapement[c]	
Year	Number of Surveys[a]	First	Last	Tributaries Surveyed[b]	Dak River Surveyed	Survey	Escapement Estimate	Chum Countability	Date	Count	Expansion	NuSEDS	Quality
1994	1–7	01-Jul	13-Sep	6	Y	Boat, Walk	Not Specified	Not Recorded	28-Aug	4,098	2.1	8,500	4
1995	2–9	14-Jul	18-Sep	7	Y	Walk	Not Specified	Not Recorded	02-Aug	4,278	1.4	6,000	4
1996	5–10	15-Jul	22-Sep	7	Y	Walk	Not Specified	Excellent	18-Aug	506	2.6	1,320	4
1997	1–3	01-Aug	04-Sep	5	N	Walk	No Estimate	Not Recorded	04-Sep	69		blank	6
1998	2–13	16-Jul	31-Oct	7	Y	Plane, Walk	Not Specified	Not Recorded	20-Aug[e]	3,630	3.5	12,530	4
1999	1–5	25-Jul	05-Oct	7	Y	Walk	Not Specified	Good	17-Aug	503	3.0	1,500	4
2000	2–9	02-Aug	09-Oct	6	Y	Walk	Not Specified	Not Recorded	31-Aug	197	8.6	1,696	4
2001	3–13	21-Jul	21-Oct	7	Y	Walk	Not Specified	Good	21-Aug	609	1.4	870	4
2002	0	-	-			Not Surveyed	No Estimate		-			AP	6
2003[d]	1	28-Aug	-	1	Y	Walk	No Estimate	Good	29-Aug	333		AP	6
2004	1–5	02-Aug	08-Oct	7	Y	Walk	No Estimate	Medium	05-Aug	555		AP	6
2005	1–7	25-Jul	01-Oct	7	N	Walk	No Estimate	Not Recorded	12-Aug	116		AP	6
2006	1–3	19-Jul	16-Sep	7	Y	Walk, Heli (Dak)	No Estimate	High	16-Sep	352		AP	6
2007	0	-	-			Not Surveyed	No Estimate		-			NI	6
2008	1	07-Aug	-	3	N	Walk	No Estimate	High	-	2		AP	6
2009	0	-	-			Not Surveyed	No Estimate		-			blank	6
2010	1	31-Aug	-	2	N	Walk	No Estimate	High	-	122		AP	6
2011	5	09-Aug	14-Sep	3	N	Walk	No Estimate		-	14		AP	6
Min	0			1					02-Aug	69	1.4	870	4
Max	13			7					16-Sep	4,278	8.6	12,530	6
Avg				5					22-Aug	1,736	3.2	4,631	5

[a] Several Kitsault River tributaries are assessed as part of the Kitsault surveys. The number of surveys conducted in each tributary varied each year.

[b] Tributaries assessed in a given year can include: Kitsault River side-channels, Dak River, Falls Creek, Gwunya Creek, La Rose Creek, Klayduc Creek, Layall Creek, and Stark Creek.

[c] Escapement estimate quality (see Table 2 for full description): 1, 2, & 3 = high; 4 = medium; 5 = low; 6 = no estimate.
AP = Adults Present; NI = Not Inspected; blank = no entry in NuSEDS.

[d] Volunteer counts of Falls, Gwunya, and Klayduc creeks were also made (before August 8) but no SILs records.

[e] Peak date is for Dak River.

Table 13. Summary of survey effort and spawner counts for non-indicator Nass Area Chum Salmon streams from1994 to 2011.

Conservation Unit	Stream Name	Years Surveyed 1994–2011	Peak Count Max	Peak Count Average	Years with Escapement Estimate	Survey Quality[a] Best	Survey Quality[a] Least	Comment
Lower Nass	Ansedagan Creek	0			0	6	6	Not surveyed for Chum Salmon
	Burton Creek	12	0	0	0	6	6	Last data from 2006
	Gingit Creek	0			0	6	6	Not surveyed for Chum Salmon
	Ginlulak Creek	0			0	6	6	Not surveyed for Chum Salmon
	Gitzyon Creek	0			0	6	6	Surveys in 2012–2014 observed Chum Salmon
	Iknouk River	12	0	0	0	6	6	No data after 2009
	Ishkheenickh River	8	11		0	6	6	No data after 2008
	Ksedin Creek	0			0	6	6	No data after 2003; glacial system
	Kwinyarh Creek	0			0	6	6	No data after 2005
	Quilgauw Creek	0			0	6	6	No data after 2003
	Seaskinnish Creek	6	2	0	0	6	6	Video weir installed in 2007, 2008, 2010 but upstream of most potential Chum spawning
	Tseax River	6	152	60	5[b]	3	6	AUC estimates since 2010
	Vetter Creek	0			0	6	6	No data after 2004
	Wegiladup Creek	0			0	6	6	No data after 2003
	Wilyayaanooth Creek	0			0	6	6	No data after 2003
	Zolzap Creek	13	80	28	2[c]	5	6	Chum Salmon counted at Coho fence installed late summer
Portland Canal-Observatory Inlet	Bear River	3			0	6	6	Volunteer counts; Chum observed in Bear Ck tributaries (Airport & Connex Creeks) in 2000
	Belle Bay Creek	14	1	0	0	6	6	One Chum Salmon observed in 2006
	Dogfish Bay Creek	17	6	1	0	6	6	Only 1 or 2 surveys per year since 2008
	Donahue Creek	12	200	24	0	6	6	Typically only 1 or 2 surveys per year
	Georgie River	8	15	3	0	6	6	Not surveyed after 2003
	Olh Creek	5	3	0	0	6	6	No data after 2008
	Perry Bay Creek	13	1,150	120	7	6	6	No data after 2009
	Roberson Creek	11	2	0	0	6	6	No data after 2007
Portland Inlet	Chambers Creek	17	54	5	4	5	6	Only 1 or 2 surveys per year since 2007
	Crag Creek	17	263	20	3	4	6	Most surveys focused on Pink and Coho
	Lizard Creek	18	613	79	5	5	6	Chum counted each year from 2003-2010
	Pirate Cove Creek	14	208	16	2	5	6	Escapement estimates produced for only 2 years (2004–2005)

[a] Escapement estimate quality (see Table 2 for full description): 1, 2, & 3 = high; 4 = medium; 5 = low; 6 = no estimate.

[b] Tally includes 2010–2014.

[c] Tally includes 2011–2012.

FIGURES

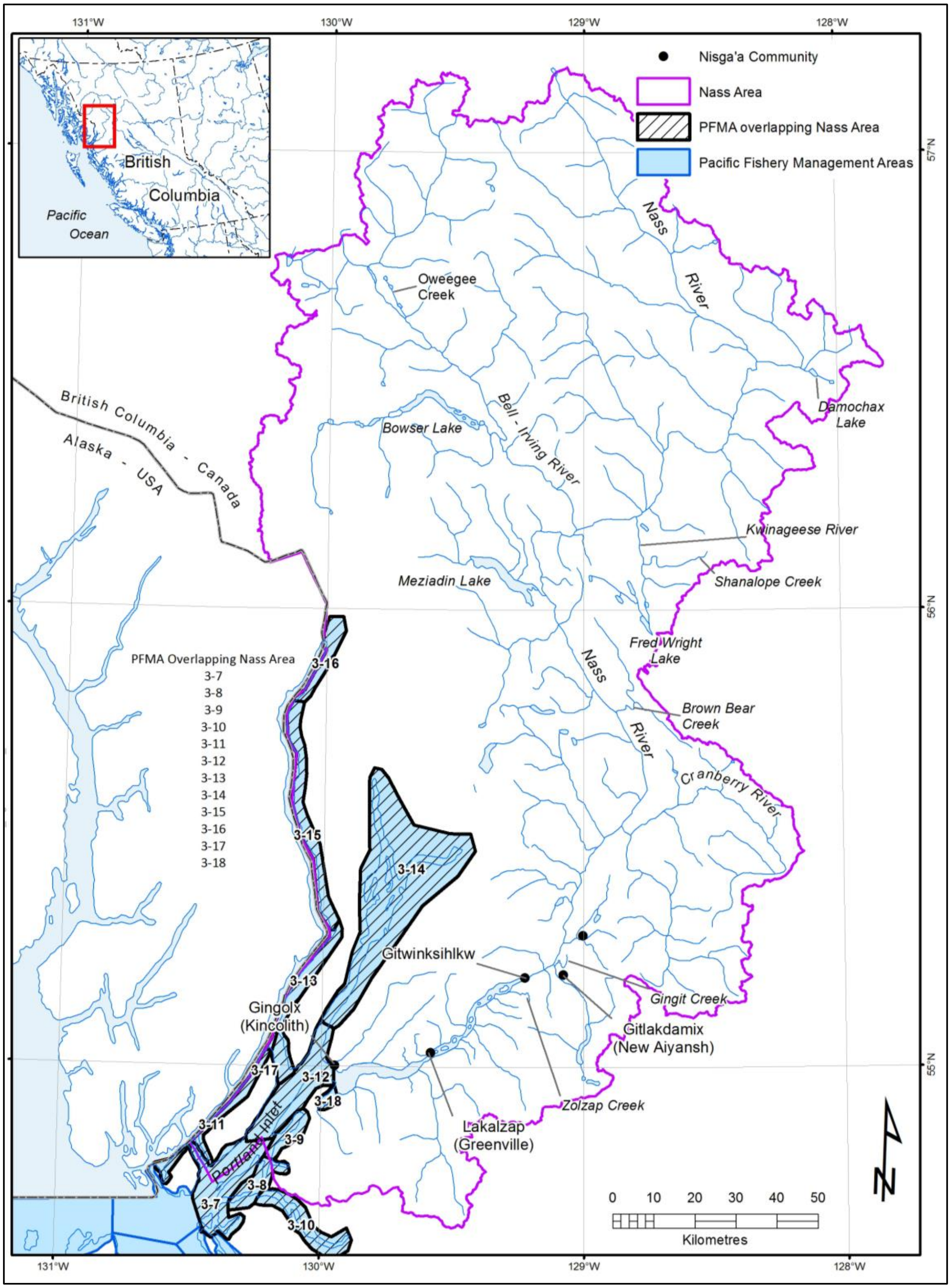

Figure 1. Pacific Fishery Management Area 3 and the Nass Area as defined by the Nisga'a Treaty.

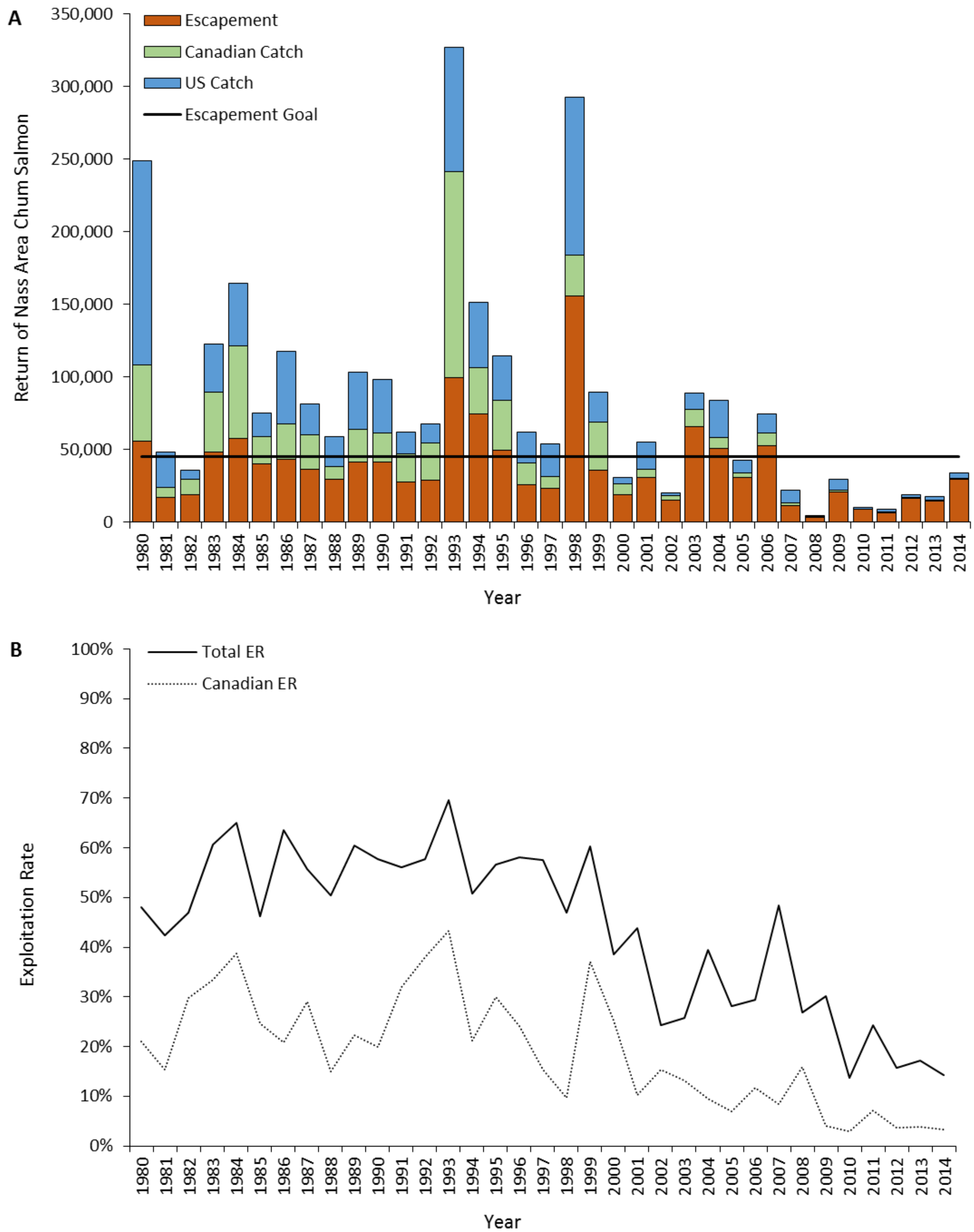

Figure 2. Nass Area Chum Salmon (A) returns and (B) exploitation rates from 1980 to 2014.

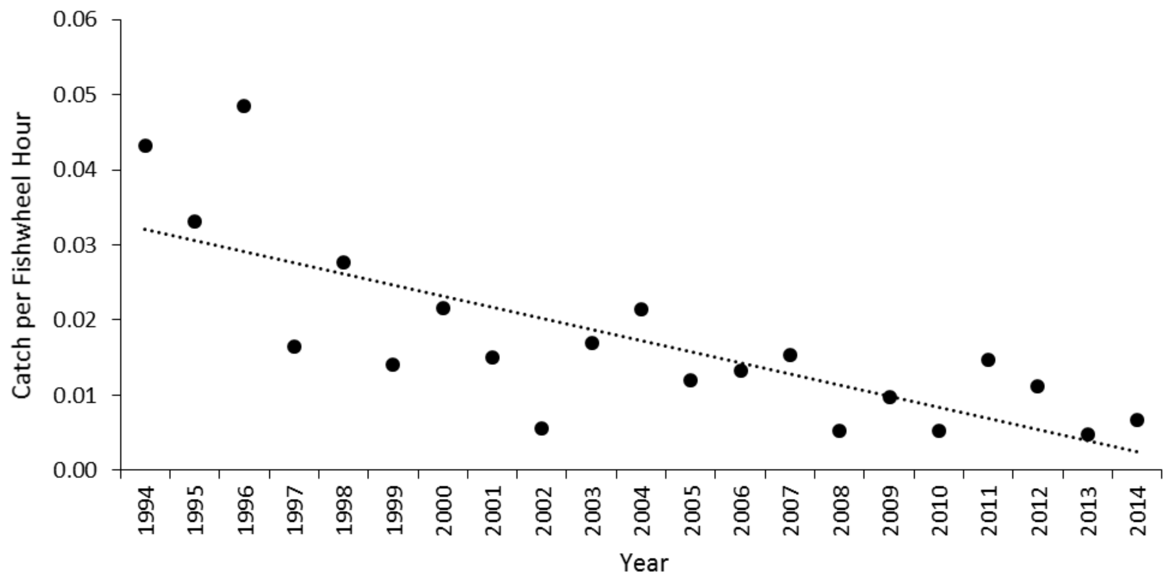

Figure 3. Declining trend in Chum Salmon catch per hour at the lower Nass River fishwheels from 1994 to 2014.

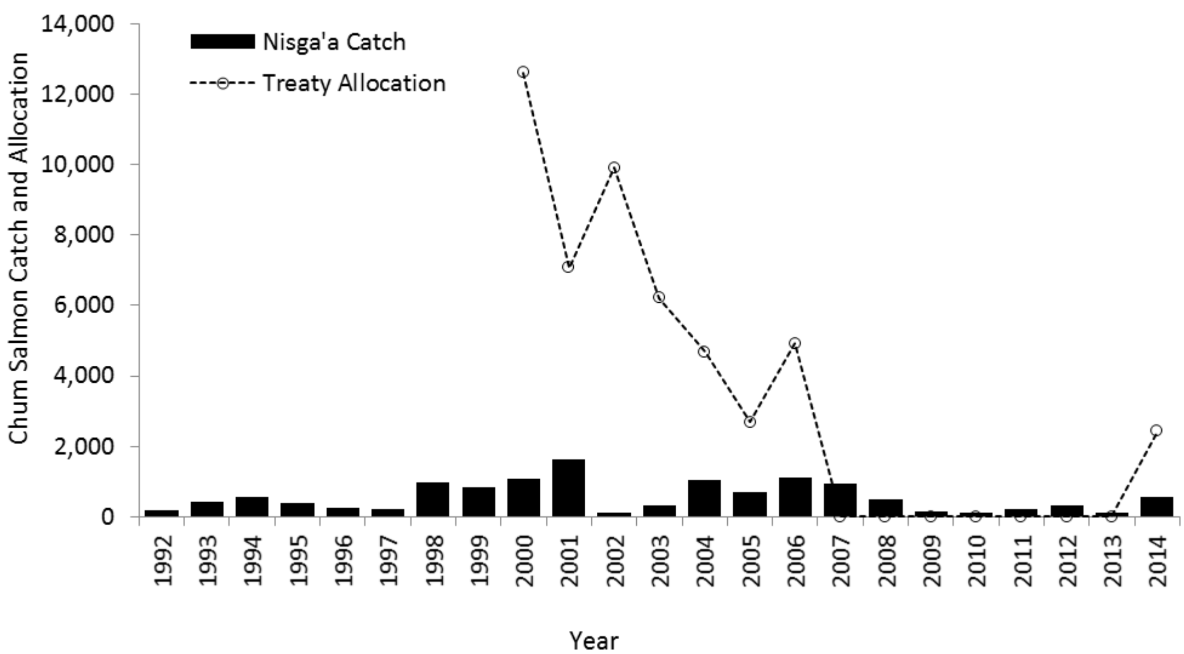

Figure 4. Nass River Chum Salmon catches in Nisga’a gillnet fisheries from 1992 to 2014 and Nisga’a Treaty allocations from 2000 to 2014.

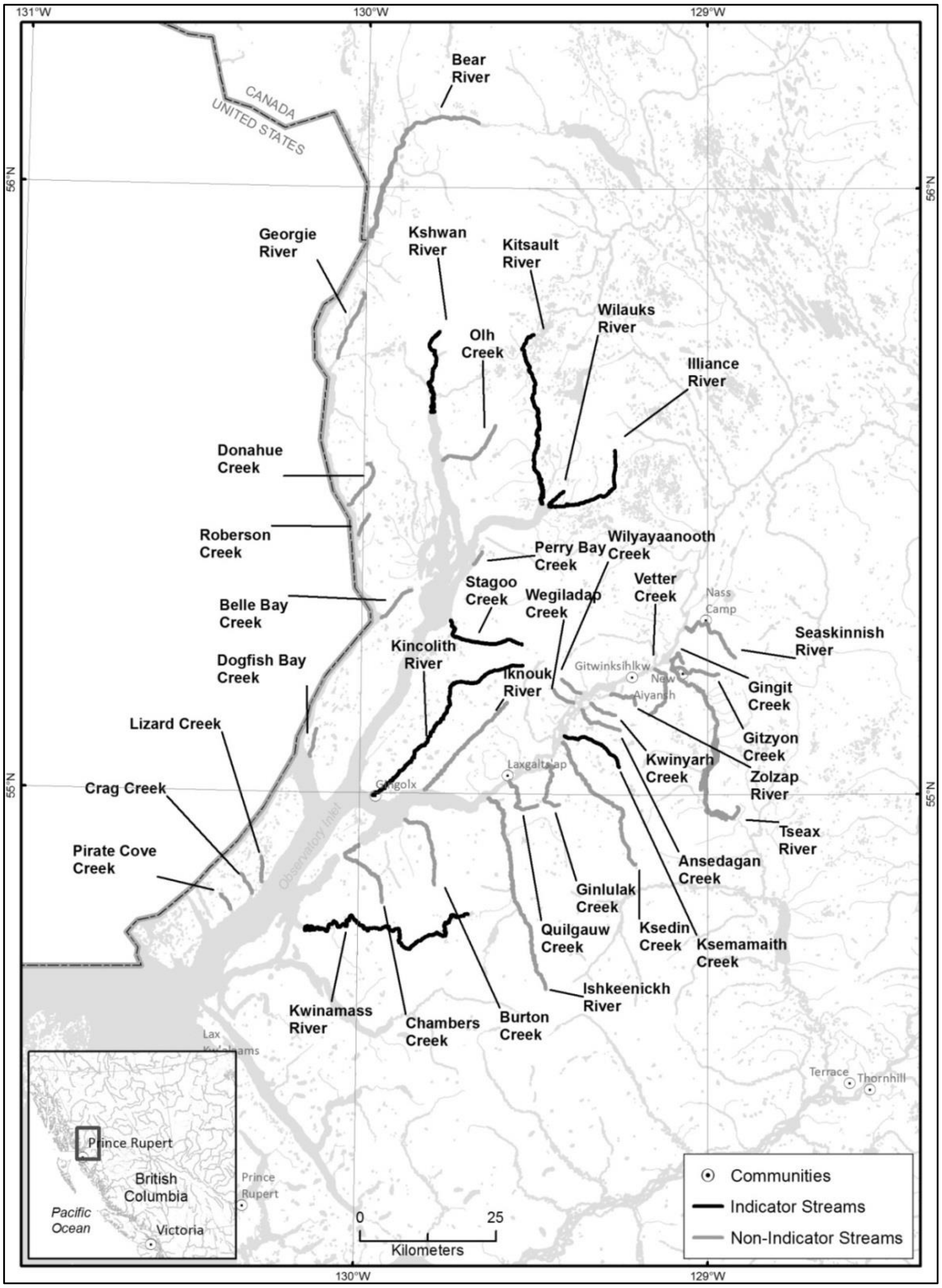

Figure 5. Location of indicator and non-indicator Chum Salmon streams in the Nass Area.

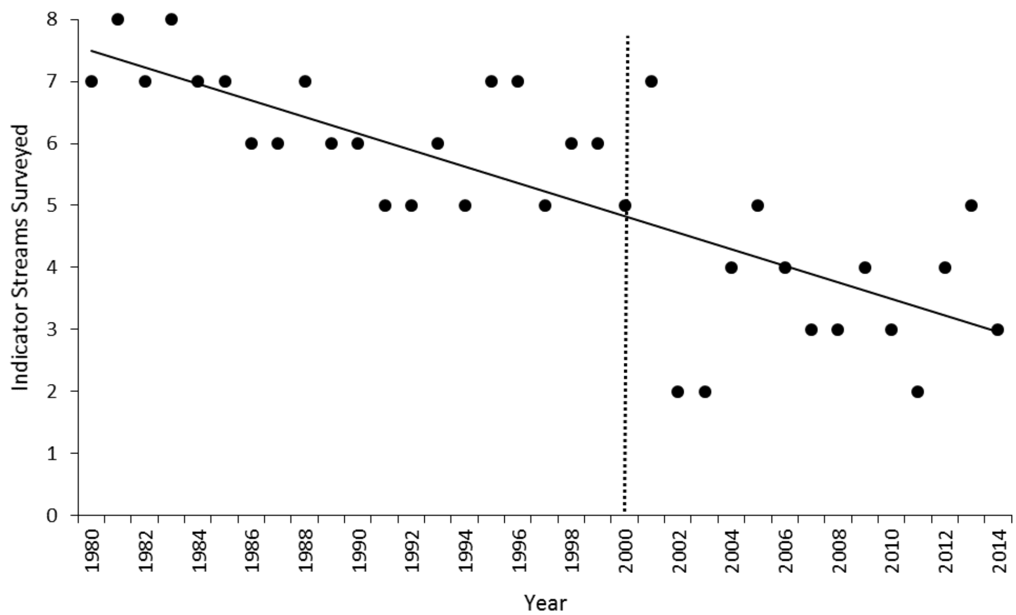

Figure 6. Declining trend in the number of Nass Area Chum Salmon indictor systems surveyed each year by DFO from 1980 to 2014. The dashed line indicates the implementation of the Nisga'a Treaty in 2000.

Figure note: Only streams with sufficient data to generate an escapement estimate are included. NFWD surveys of Ksemamaith Creek are excluded from tallies as this stream was not historically surveyed by DFO.

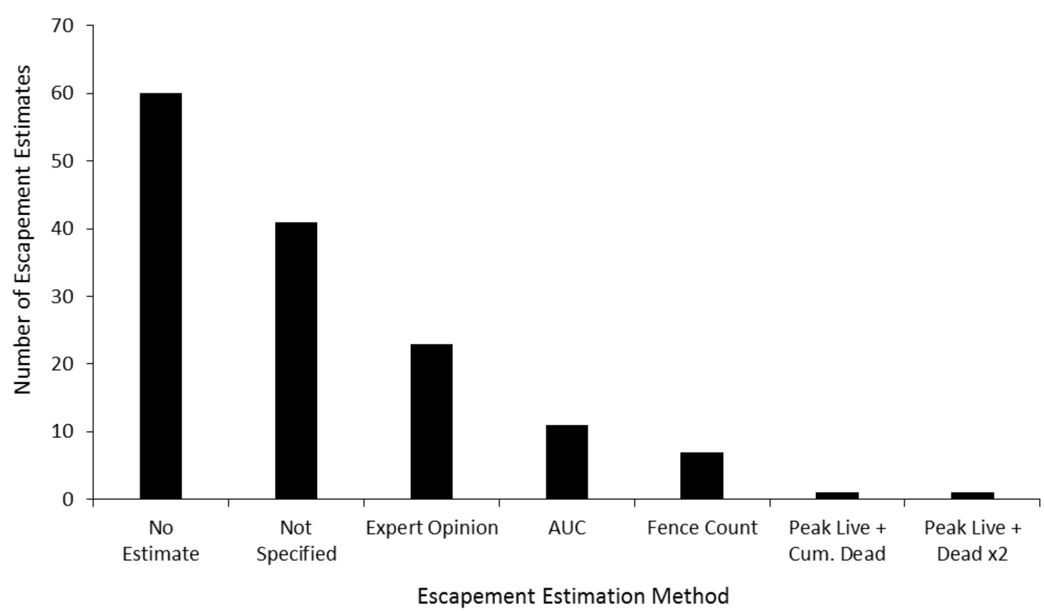

Figure 7. Methods used to generate escapement estimates for Nass Area Chum Salmon indicator streams from 1994 to 2011.

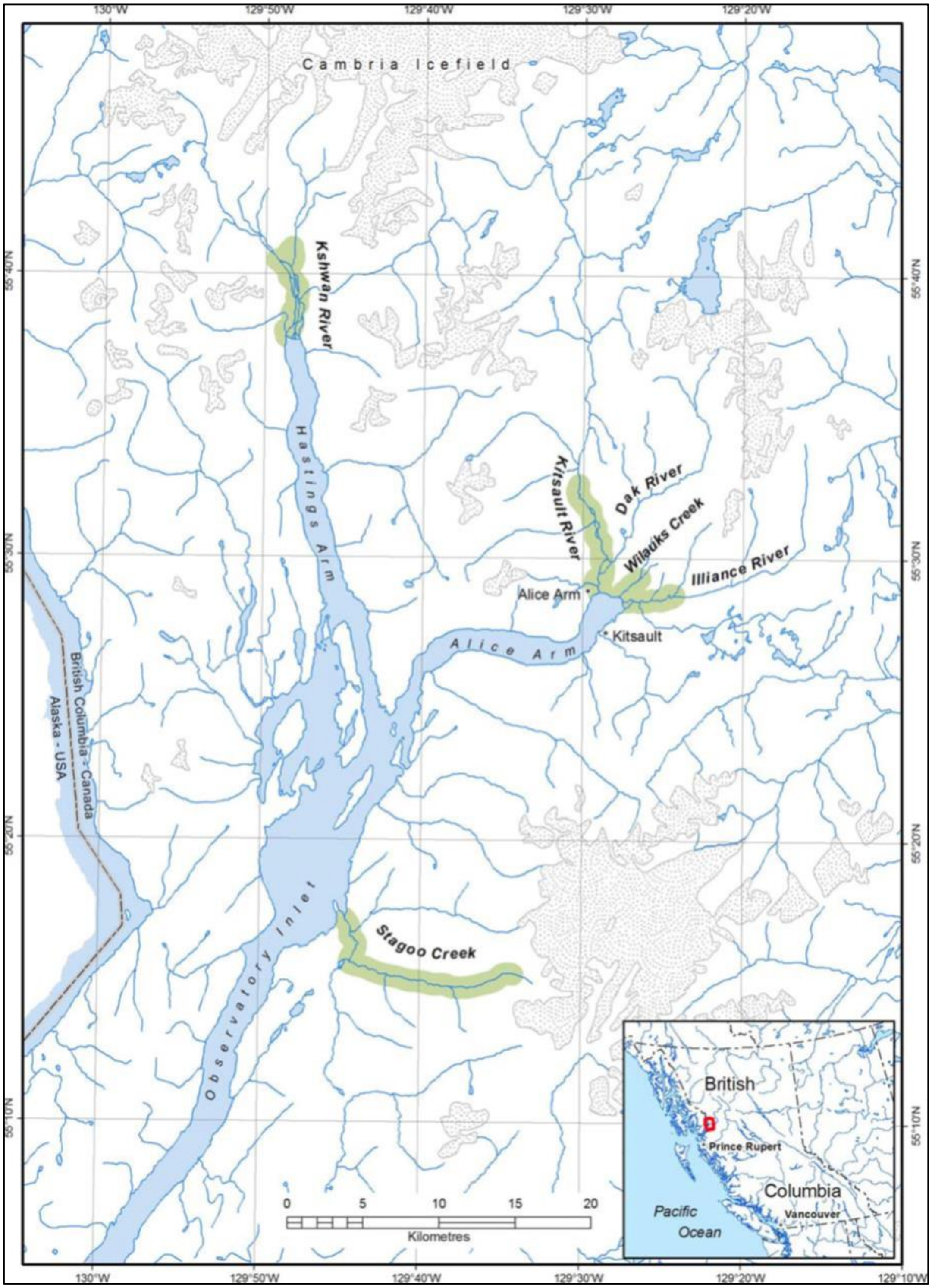

Figure 8. Observatory Inlet Chum Salmon indicator streams.

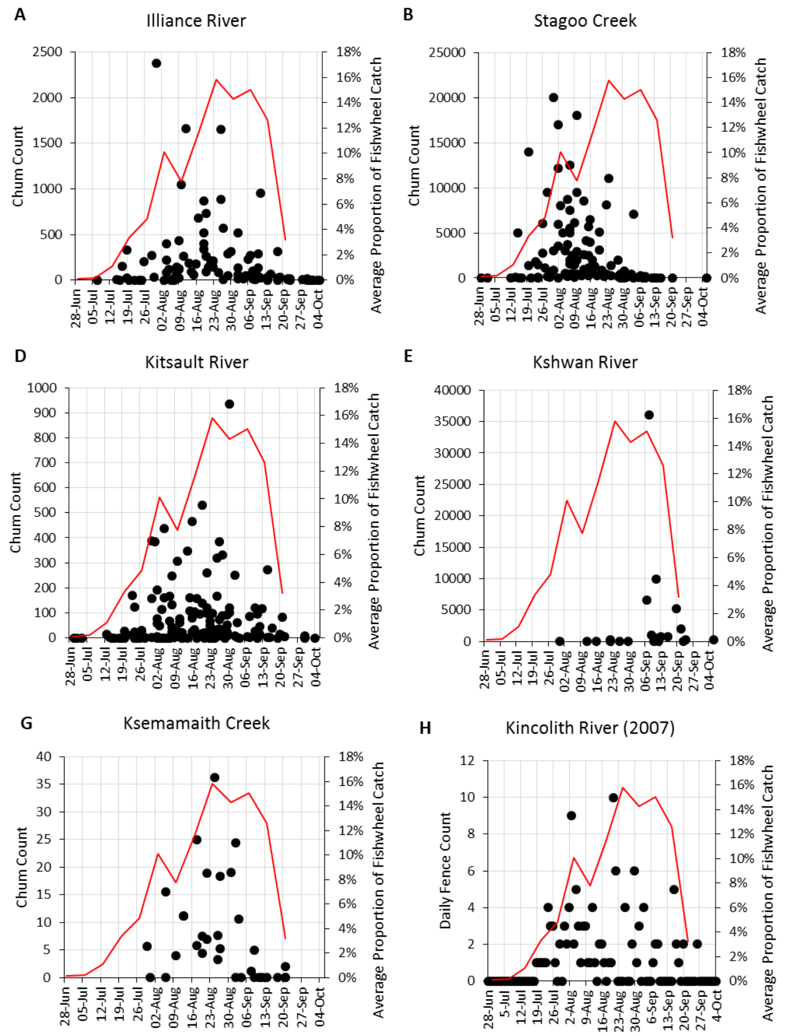

Figure 9. Nass Area Chum Salmon run timing based on counts from Stream Inspection Logs (SILs) [(A) Illiance River, (B) Stagoo Creek, (C) Wilauks Creek, (D) Kitsault River, (E) Kshwan River, and (F) Kwinamass River], NFWD surveys [(G) Ksemamaith Creek], and fence counts [(H) Kincolith River].

Figure note: The red line represents the migration timing curve used by English et al. (2012) to adjust weekly harvest rates for the proportion of Area 3 Chum Salmon migrating through fisheries.